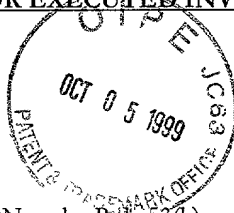


IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
REQUEST FOR FILING APPLICATION UNDER 37 CFR 53(b)
WITHOUT FILING FEE OR EXECUTED INVENTOR'S DECLARATION

Assistant Commissioner for Patents
Washington, D.C. 20231

Atty. Dkt. 2687-8
Date: October 5, 1999



Sir:

This is a request for filing a new PATENT APPLICATION under Rule 53(b) entitled:

ARRANGEMENT FOR IMPROVING AVAILABILITY OF SERVICES IN A COMMUNICATION SYSTEM

without a filing fee and/or without an executed inventor's oath/declaration.

This application is made by the below identified inventor(s). Attached hereto are the following papers:

☒ An abstract together with
pages of specification and claims including
numbered claims and also attached are
sheets of accompanying drawings (Figs. 1-12).

This application is based on the following prior foreign application:

Application No.	Country	Filing Date
971605	Norway	08 April 1997

ively, the entire content of which is hereby incorporated by reference in this application, and priority is hereby claimed therefrom.

This application is based on the following prior provisional application(s):

Application No.	Filing Date
-----------------	-------------

respectively, the entire content of which is hereby incorporated by reference in this application, and priority is hereby claimed therefrom.

☐ Certified copy/ies of foreign applications attached.

This application is a ☐ continuation/☐ division/☐ continuation-in-part of application Serial No. , filed

Please amend the specification by inserting before the first line: --This application is a ☐ continuation/☐ division/☐ continuation-in-part of application Serial No. , filed , the entire content of which is hereby incorporated by reference in this application.--

☒ Please amend the specification by inserting before the first line: --This is a continuation of PCT application No.

PCT/NO98/00104, filed 2 April 1998, the entire content of which is hereby incorporated by reference in this application.--

Please amend the specification by inserting before the first line: --This application claims the benefit of U.S. Provisional Application No. , filed , the entire content of which is hereby incorporated by reference in this application.--

☒ Preliminary amendment to claims (attached hereto), to be entered before calculation of the fee.

☒ Also attached. Notice Informing the Applicant of the Communication of the International Application to the

Designated Offices (Form PCT/IB/308) / Information Concerning Elected Offices Notified of Their Election (Form

PCT/IB/322) / Notification Concerning Submission of Transmittal of Priority Document (Form PCT/IB/304) / International

Preliminary Examination Report (Form PCT/IPEA/409) with seven (7) amended claim sheets / International Search Report

(PCT/ISA/210) / Information Disclosure Statement / Form PTO-1449 / 4 references

1. Inventor:	Thanh	Van	DO	Norway
	(first)	MI	(last)	(citizenship)
Residence: (city)	Oslo		(state/country)	Norway
Post Office Address:	Stjernemyrveien 28, Oslo, Norway			
(incl zip code)	N-0673			

Address all future communications to NIXON & VANDERHYE P.C., 1100 North Glebe Road, 8th Floor, Arlington, Virginia 22201.

1100 N. Glebe Road, 8th Floor

Arlington, Virginia 22201

Telephone: (703) 816-4000

Facsimile: (703) 816-4100

NIXON & VANDERHYE P.C.

By Atty.: John R. Lastova, Reg. No. 33,149

Signature: John R. Lastova

JRL:mm

The PTO did not receive the following
listed item(s) an abstract

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

DO

Atty. Ref.: 2687-8

Serial No.

Group:

Filed: October 5, 1999

Examiner:

For: **ARRANGEMENT FOR SIMPLIFYING THE
DESIGN AND IMPLEMENTATION OF
MOBILE SERVICES IN A
COMMUNICATION SYSTEM**

October 5, 1999

Assistant Commissioner for Patents
Washington, DC 20231

PRELIMINARY AMENDMENT

Sir:

Prior to calculation of the filing fee and examination the merits, please amend the above-identified application as follows:

IN THE CLAIMS:

Please amend claims 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 17, 21, 23, and 25 as follows:

3. (*Amended*) Arrangement as claimed in [claims 1 or 2] claim 1, characterized in that said mobility transparency means are introduced to the application designers at the requirement and functional specification phases, i.e. , by integrating mobility function (M) totally into the infrastructure of a platform.

4. (*Amended*) Arrangement as claimed in [any of the preceding claims] claim 1, characterized in that said mobility transparency means are so adapted that computational objects are mapped to engineering objects (EO) so as to be none-visible in the computational model of the application in question.

5. (*Amended*) Arrangement as claimed in [any of the preceding claims] claim 1, characterized in that the mobility function constitutes the engineering object interceptor, i.e. , being arranged at the boundary between the terminal domain and the telecom system domain.

DO
Serial No.

6. (*Amended*) Arrangement as claimed in [any of the preceding claims] claim 1, characterized in that an engineering model is developed by letting each computational object (CO) be mapped to one or more Basic Engineering Objects (BEOs), interaction between computational objects (CO1, CO2) belonging to the same cluster being effected directly as method calls, and communications between [computunal] computational objects (CO3, CO4) located in the telecom system domain and in different clusters being effected through a channel comprising stubs, binders and protocols.

7. (*Amended*) Arrangement as claimed in [any of the preceding claims] claim 1, characterized in that communication between user domain computation objects (CO2) and telecom system domain computation object (CO3) residing in different clusters will take place in a channel comprising an interceptor () in addition to the usual objects, said interceptor being invisible for the application designer.

8. (*Amended*) Arrangement as claimed in [any of the preceding claims] claim 1, characterized in that from the computational model the application designer can decide whether an object belongs to the user domain or the telecom system domain, for on the basis of such a decision to generate the necessary objects, such as stubs, for all the application objects.

9. (*Amended*) Arrangement as claimed in [any of claims 1-2] claim 1, characterized in that the arrangement comprises means for sending a message to a routing broker asking for specific server to perform a task, said broker locating the server and sending said request to said server, said mobility functions (M) thereby playing the role as the broker.

10. (*Amended*) Arrangement as claimed in [any of the claims 1-2 or 9] claim 1, characterized in that said mobility function (M) comprises a cascade of two brokers.

11. (*Amended*) Arrangement as claimed in [any of the claims 1-2 or 9-10] claim 1, characterized in that said mobility functions (M) in the form of two brokers allows for interaction between an object (CO1) belonging to a user domain and an object (CO2)

DO
Serial No.

belonging to a telecom system domain by letting said interactions enter said mobility functions (M) at one end and exit therefrom at the other end [(Fig. 5)].

12. (*Amended*) Arrangement as claimed in [any of the claims 1-2 or 9-11] claim 1, characterized in that both ends of the mobility functions (M) support both the same interface type containing an “invoke type” operation, for thereby allowing a request to be built and invoked dynamically by client objects.

14. (*Amended*) Arrangement as claimed in [any of the claims 1-2, or 9-13] claim 1, characterized in that the mobility functions (M) are introduced in the system architecture as a functional layer between the application layer and the DPE layer, said layer separation allowing every layers to use services offered by other layers.

15. (*Amended*) Arrangement as claimed in [any of the claims 1-2, or 9-14] claim 1, characterized in that there is introduced an intermediary model called derived computational model in the transition from the computational model to the engineering model, said intermediary model being used to map all interactions traversing the boundary between the user domain and the telecom system domain to interactions with the mobility functions (M).

16. (*Amended*) Arrangement as claimed in claim 15, characterized in that on the basis of the derived computational model, an engineering model can be elaborated and engineering objects, such as stubs, can be mechanically generated.

17. (*Amended*) Arrangement as claimed in [any of the claims 1-2] claim 1, characterized in that said arrangement comprises proxy objects, a proxy acting on behalf of an entity in a transparent way, i.e., when interacting with a proxy an entity cannot tell whether it is dealing with the real counterpart or with its proxy.

21. (*Amended*) Arrangement as claimed in [any of the claims 1-2 or 17-20], characterized in that there is introduced an object type designated Dynamic Object (DO), all proxies being of the type DO, and that a proxy, i.e., an object (instance) of type DO is initiated from an object template called Dynamic Object Implementation (DOI).

DO
Serial No.

23. (*Amended*) Arrangement as claimed in [any of the claims 1-2 or 17-22] claim 1, characterized in that any object wanting to interact with objects in a different domain are registered in the mobility functions (M), the registration of the necessary objects for an application being done for example at the [initialisation] initialization by an object which is [customised] customized for the configuration, the definition and creation of a proxy conveniently being done together with the registration of the object it is representing.

25. (*Amended*) Arrangement as claimed in [any of the claims 1-2 or 17-24] claim 1, characterized in that there is introduced a new redirection function on the DPE in question, as well as the possibility of generating special stub for any dynamic objects.

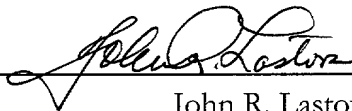
REMARKS

By the foregoing amendment, Applicant has eliminated the multiple claim dependencies of claims 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 17, 21, 23, and 25 in order to minimize the filing fee. Applicant has also corrected minor typographical errors appearing in claims 3, 5, 6, 16, 17, 21, and 24.

Prompt and favorable examination on the merits is respectfully requested.

Respectfully submitted,

NIXON & VANDERHYE P.C.

By: 
John R. Lastova
Reg. No. 33,149

JRL:mm
1100 North Glebe Road, 8th Floor
Arlington, VA 22201-4714
Telephone: (703) 816-4000
Facsimile: (703) 816-4100

ARRANGEMENT FOR SIMPLIFYING THE DESIGN AND IMPLEMENTATION
OF MOBILE SERVICES IN A COMMUNICATION SYSTEM

FIELD OF THE INVENTION

5

The present invention relates to an arrangement for simplifying the design and implementation of mobile services in a communication system, especially a telecommunication system, said system comprising distributed hardware and software components which interact in order to provide services to one or more users.

BACKGROUND OF THE INVENTION

15 The present invention has been developed on the basis
that prior art defined distribution transparencies are
not sufficient to support mobility.

More specifically the present invention has been developed on the basis of considering mobility as an additional transparency.

In other words, the invention suggests the provision of the mobility support functions in a transparent way, i.e. the application designer needs not to be aware or concerned about the necessary mechanisms and function to support mobility and can concentrate on his application design. Mobility can hence be considered as a new transparency in addition to the ones defined by ODP (Open Distributed Processing) [ITUa] and adopted by TINA (Telecommunication Information Networking Architecture) [TIN95i].

According to ODP/TINA, a telecommunication application is realized by a set of interacting computational objects

which rely on an abstract infrastructure called Distributed Processing Environment (DPE). The DPE hides the complex details of mechanisms used to overcome problems caused by distribution.

5

The process of hiding the effect of distribution is known as distribution transparency in the Open Distributed Processing Reference Model (RM-ODP). The application designers do not need to be aware of the mechanisms necessary to deal with different aspects of distribution and can therefore focus on their application specification. When addressing the distribution of their applications, they only have to express their requirements for transparencies. The properties of distribution is hidden or transparent to the end-users and the application designers in the enterprise, information and computational viewpoints.

The engineering viewpoint defines the mechanisms and functions by which those transparencies are realised. Each set of transparency properties requires the use of a set of standard functions in a specified way.

The distribution transparencies defined by ODP/ TINA are:

- 25 • Access transparency
- Location transparency
- Federation transparency
- Migration transparency
- Transaction transparency
- 30 • Replication transparency
- Failure transparency
- Resource transparency
- Concurrency transparency

As shown in Figure 1, a DPE consists of several DPE nodes A, B and C. A DPE node is a unit of resource administration providing support to the DPE architecture. The part of the DPE node supporting the DPE architecture is called a DPE platform. The computing resource supporting a DPE platform is called Native Computing and Communication Environment (NCCE). Even if the NCCE can itself be locally distributed, there is only one DPE platform associated with a DPE node.

10

A DPE platform shields the objects from the potential heterogeneity of the NCCE on which they are executed. Not all the transparencies are required to be provided by a DPE platform but only the ones called fundamental. Access transparency and location transparency are the two transparencies which are considered fundamental in the DPE architecture.

15

STATE OF THE ART

20

Mobility support functions are implemented and offered in different systems such as UPT (Universal Personal Telecommunication) and networks such GSM (Global Mobil System) but never in a transparent way. In order to build new application, the designers must take into account and know fairly well about the mobility support functions. ODP/TINA introduced an efficient framework for designing and implementing distributed applications but assume that mobility is inherently supported. In fact, mobility is not inherently supported. When a terminal which is a DPE node is moving, disappearing and reappearing some moment later at another place, additional mobility functions must be introduced and preferably in a transparent way. In other words, mobility transparency is required.

25

30

655004 " 44334430

PROBLEMS RELATED TO PRIOR ART

The design of mobile applications, i.e. applications
5 available to the mobile users, is complex and time-
consuming because the designer has to take into account
mobility functions which are quite complex and numerous.
It is also difficult and time-consuming to make existing
fixed applications available to mobile users, i.e. mobile
10 without mobility transparency.

OBJECTS OF THE PRESENT INVENTION

An object of the present invention is to improve the
15 availability of services in a communication system espe-
cially as seen from an application designer's point of
view.

Another object of the present invention is to provide the
20 application designer with a tool which is not concerned
about the necessary mechanism and function regarding sup-
porting mobility.

Yet another object of the present invention is to provide
25 the designer of applications with a tool whereby the de-
signer has not to take into account mobility functions.

Still another object of the present invention is to pro-
vide a tool by which the designer of applications can
30 make fixed applications available to mobile users in a
simplified and less time-consuming way.

SUMMARY OF THE INVENTION

The above objects are achieved in an arrangement as stated in the preamble, which according to the present invention is primarily characterized by introducing in said system a mobility transparency, for thereby enabling facilitated application design included inter alia terminal or personal mobility, as well as session mobility both in a continuous way and in a discrete way.

In other words, it is according to the present invention suggested a new transparency, called mobility transparency which is introduced and has for its main object to hide all the necessary mechanisms and functions to support mobility to the application and the application designer. According to the present invention this mobility transparency can also be considered as a new transparency in addition to already existing transparency, for example in addition to the ones defined by ODP (Open Distributed Processing) and adapted by TINA (Telecommunication Information Networking Architecture).

Further features and advantages of the present invention will appear from the following description taken in connection with the enclosed drawings, as well as from the appending patent claims.

BRIEF DISCLOSURE OF THE DRAWINGS

Fig. 1 illustrates schematically a physical infrastructure relating to a distributed processing environment (DPE) consisting of several DPE nodes.

Fig. 2 illustrated schematically the mobility functions which will be implemented according to the present invention.

Fig. 3 is an example of an embodiment according to the present invention, wherein the mobility functions are totally integrated in the infrastructure of platform, representing the in-line alternative.

Fig. 4 is a schematical block diagram illustrating another field of application according to the present invention, wherein the broker in client/server interactions are utilised.

Fig. 5 is a schematical diagram illustrating the embodiment wherein the user agents are acting as routing brokers.

Fig. 6 is a schematical diagram illustrating further details of an embodiment including the broker alternative.

Fig. 7 is a schematical block diagram illustrating still another embodiment of the present invention, wherein proxies are used to untie the binding between the application and the mobility functions.

Fig. 8 illustrated schematically possible configurations at run-time.

Fig. 9 illustrates an information model for the proxy.

Fig. 10 illustrates schematically the relationship between objects, interfaces and identifiers in the computational and engineering viewpoints.

Fig. 11 illustrates further details related to the redirection of operation request to the proxy.

Fig. 12 is a schematical diagram illustrating the computational model of the application in the proxy alternative, especially related to the configuration of the application at installation by which the plant engineer can derive the registration of objects to the mobility functions and the creation of necessary proxies.

DETAILED DESCRIPTION OF EMBODIMENTS

10

In the following there will be given detailed descriptions of embodiments according to the present invention.

As stated in the preamble, the main object of the present invention is to introduce a so-called mobility transparency in order to hide all the necessary mechanisms and functions to support mobility to the application and the application designer.

20 In the following there will be discussed three alternative solutions in which mobility transparency can be provided, namely by the in-line alternative, by the broker alternative, as well as by the proxy alternative.

25 As previously discussed in connection with Fig. 1 a telecommunication application is realised by a set of interacting computational objects which rely on an abstract infrastructure called Distributed Processing Environment, DPE, said DPE hiding the complex details of mechanisms used to overcome problems caused by distribution. Further, as appearing from Fig. 1 a DPE consists of several DPE nodes A, B and C, a DPE node being a unit of resource administration providing support to the DPE architecture.

Now, turning to Fig. 2 there is illustrated a block designated M, which represents all the functions necessary to support mobility, such as terminal support functions, personal support functions, session support functions,
5 mobility-related support functions, etc.

In the following there will successively be disclosed how M is introduced into the whole system in all three alternatives.

10

THE IN-LINE ALTERNATIVE

The most straightforward alternative to make mobility transparent to the application designers at the requirements and functional specification phases, is to integrate the mobility functions M totally into the infrastructure or platform. All the computational objects will not be mapped to basic engineering objects (BEO) but to engineering objects (EO) and will hence not be visible in
15 the computational model of the application. In fact, the mobility function constitutes the engineering object interceptor, standing at the boundary of two domains: the terminal domain and the telecom system domain. This solution is also called in-line because the support of mobility is introduced directly embedded into the platform.
20
25

In Figure 3, we show as example an application consisting of four computational objects CO1, CO2, CO3 and CO4. CO1 and CO2 are grouped together into cluster 1 and belong to the user domain. CO3 and CO4 belong to the telecom system domain but are assigned to clusters 2 and 3.
30

From the given computational model, an engineering model can be developed. Each Computational Object (CO) is

mapped to a Basic Engineering Object (BEO). Of course, a CO can also be mapped to several BEOs but for the sake of simplicity we do not choose this mapping here. Since CO1 and CO2 are within the same cluster, interactions between them can be done directly as method calls. Communications between CO3 and CO4 go through a channel consisting of stubs, binders and protocols since they belong to different clusters. Communications between CO2 and CO3 go also through a channel because CO2 and CO3 reside in different clusters, but the channel will now contain an interceptor in addition to the usual objects because it crosses the boundary between two domains (terminal domain and telecom system domain). However, the interceptor is not visible for the application designer and does not have any consequence for the application objects. It is worth noting that the application designer does not need to think about the terminal domain in the computational model (upper part of Figure 3). In the engineering model (lower part of Figure 3) there is also drawn a borderline between the application layer and the DPE/platform layer. This borderline is in fact not a real and existing border but just a virtual one. In showing that, we aim to visualise that the mobility functions M is fully integrated in the DPE.

25

If the mobility functions M is implemented and fully integrated into the platform and there exist development tools able to generate channels containing the mobility functions as interceptor, then the design and implementation of mobile applications are no more complex than the ones of fixed applications. From the computational model, in addition to the usual grouping of objects into clusters, capsules, etc., the application designer has to decide whether an object belongs to the user domain or the

telecom system domain. Once the decisions are made, the necessary objects such as stubs can be generated for all the applications objects. The application designer just need to implement the programming codes which are specific to his application domain.

The presented alternative has many advantages. It succeeds in making mobility transparent to the applications. It can be optimised to become very efficient. It is also conformed to the RM-ODP specifications concerning the channel concept.

There are however some disadvantages. From the application point of view, there may be a lack of flexibility in the sense that objects, once allocated, are not allowed to migrate from the user domain, i.e. from the mobile side of the system to the telecom system domain or vice versa. The boundary between the user domain and the telecom system domain constitutes a very rigid borderline which may not be wanted. From the platform point of view and also from the mobility functions point of view, it may not be desirable to tie closely the mobility functions to the platform. The platform should be general enough to fit most distributed systems without major modifications, while the mobility functions, as its name tells, should be generic and easy to be customised for a specific system. It is therefore desirable that the construction of the platform and the mobility functions could be done independently and by different parties.

THE BROKER ALTERNATIVE

The broker concept

In this alternative, we introduce and use a notion called

broker defined in "Understanding Corba" [OPR96]. A broker is a specialised server object acting as intermediary between one or more client objects and one or more server objects. As shown in Figure 4, a broker represents a client when the client makes a request to a server and represents a server when a server makes a response to a client.

There are defined two brokering schemes:

10

1. Introduction brokering

In an introduction brokering scheme active servers register with the broker to make themselves known in the system. The client can then send a message to the broker asking for a server that can perform some task. The introduction broker selects a server to perform the task and returns information to the client accessing that server. The broker introduces the server to the client, so that the client and the server can contact each other directly. This brokering scheme corresponds the RM-ODP trading function [ITUc].

20

2. Routing brokering

In a routing brokering scheme, the clients sends a message to the broker asking for a server that can perform some task. The routing broker then selects a server to perform the task and sends the client's request to that server. The broker handles all communications; no direct communication between the client and the server ever takes place.

30

MOBILITY FUNCTIONS M AS ROUTING BROKER

In the second solution we adopt the concept of routing brokering with a minor modification. The client send a
5 message to the routing broker not asking for any server
able to perform the task but asking for a definite server
to perform this task. The broker locates the server and
sends the client's request to that server. The mobility
functions M will play the broker role. And since an ob-
10 ject may play both the roles of client and server, the
mobility function M will be a a cascade of two brokers.

The Figure 5 shows how an object CO1 belonging to the
user domain interacts with an object CO2 belonging the
15 telecom system domain. Interactions enter the mobility
functions M at one end and exit at the other.

Both ends of the mobility functions M support both the
same interface type containing an "invoke type" opera-
20 tion. This operation originates from the same concept as
the one used in the Dynamic Invocation Interface (DII)
defined in CORBA [OPR96], [Obja]. This concept allows re-
quest to be built and invoked dynamically by client ob-
jects. The client object needs to know interface-related
25 information only at the invocation time. No knowledge is
necessary at compilation time. The Invoke is composed of
an object name (or identifier), an operation name, and a
parameter list for the invoked operation.

30 An IDL (Interface Definition Language) [Obja] of such In-
voke operation is given below.

The **name** is the name or identifier of the object where
the call is to be made. The **ctx** contains information

about the client object, environment, or circumstances of a request that are convenient to pass as parameters. The **operation** is the same operation identifier that is specified in the interface definition of the server object.

- 5 The **arg_list** contains a list of arguments for the operation. The operation **result** will be placed in the result argument after the invocation completes.

```

Interface MobInvocation {
10      Invoke ( in Object target;           //object to be
               in Context ctx;             //context of op
               in Identifier operation;     //intended ope
               in NVList arg_list;         //args to op
               inout NamedValue result     //operation re
15
      };

```

IDL specification of the MobInvocation interface

- The application designer can decide how a client object
- 20 can call the operation **Invoke** of the mobility functions **M**. If calls are to be made in a static way then the stub generated from the interface **MobInvocation** must be included in the client object code at compilation time. If calls are to be made dynamically, e.g through the Dynamic
- 25 Invocation Interface (DII) [**Objb**], than the information about the interface **MobInvocation** is only needed at run time but not at compilation time.

- After entering the mobility functions at the first end
- 30 and traversing several other objects, the invocation arrives at the other end. In order to avoid a static binding between the mobility functions **M** and an arbitrary object, and allowing independent development, the DII is again used. Hence, the mobility functions **M** does not need
- 35 any interface information of the server object at compilation time.

In this alternative, the mobility functions M is introduced in the system architecture as a functional layer between the application layer and the DPE layer. It is
5 worth noting that the mentioned layer separation is functional and not hierarchical in the sense that every layers can use services offered by other layers. Assuming that the interfaces between layers are well defined, the inside structure of a layer is not relevant to other layers
10 and can be modified without any serious implications.

Let us now return to the same example as in the previous paragraph with four computational objects CO1, CO2, CO3 and CO4. As shown in Figure 12, we start with the same
15 computational model but an intermediary model called derived computational model is introduced in the transition from the computational model to the engineering model. This intermediary model is used to map all interactions traversing the boundary between the user domain and the
20 telecom system domain to interactions with the mobility functions M. From the derived computational model, an engineering model can be elaborated and engineering objects such as stubs can be mechanically generated.

25 This alternative has several merits. First, the mobility transparency is still preserved at the computational viewpoint. Although an additional model is necessary in the transition to the engineering viewpoint, it does not constitute a major obstacle since the derived computational model can be easily and automatically derived from
30 the computational model.

However, there is still one major limitation. As with the previous alternative, migration of objects across domain

boundaries is not allowed. Once allocate to a domain, an object is not allowed to move since interactions across domain boundaries are statically mapped to interactions with the mobility functions M. Objects originally designed without inter-domain interaction capability can not later on communicate with objects in other domains without modification and re-compilation.

THE PROXY ALTERNATIVE

10

This alternative aims to enhance further the flexibility offered by the previous alternative by loosening the closed binding between the application and the mobility functions M. This is achieved by introducing proxy objects. A proxy acts on behalf of an entity in a transparent way, i.e. when interacting with a proxy, an entity cannot tell whether it is dealing with the real counterpart or with its proxy.

20 Every object requiring inter-domain interactions is represented by a proxy object located in the same domain as the object interacting with it. When interacting with an object in a different domain, the object is actually interacting with the local proxy object of the required object of the other domain. The proxy will marshall the operation invocation into the invoke operation (as defined in the previous paragraph) at the respective end of M. If interactions are to be in both directions, we need a symmetrical constellation as shown in Figure 7. In this example an object CO1 in the user domain wants to invoke an operation **OpX()** on an object CO2 in the telecom system domain. CO1 is actually invoking **OpX** on the proxy of CO2, namely PCO2. PCO2 will marshall **OpX()** into the **Invoke** operation of M. This operation will be conveyed through the

mobility functions to the other end and M invokes `OpX()` on CO2. The result will be conveyed all the way back to CO1. It is worth noting that only PCO2, the proxy of CO2, is involved in the invocation of operations on CO2 and
5 PCO1, the proxy of CO1 is left outside in this case. The opposite situation will occur when CO2 calls operation on CO1.

It is observed that PCO2 has an interface which has the
10 same signature as the one of CO2. All operations defined for CO2 are defined for PCO2. However, all the operations of PCO2 will perform exactly the same job which is to marshall the initial operation and to call the `Invoke` operation of M.

15 CO1 may invoke the operation on CO2 in a static way or through the Dynamic Invocation Interface (DII). In the first case, the information about the interface of CO2 must be defined and available at compilation time. In the
20 second case, this information is only needed at run time.

Until this stage, the level of flexibility achieved is not higher than in the first alternative. In fact, the flexibility relies on how the proxies are introduced and
25 created. If the introduction and creation of necessary proxies are based on the domain grouping of objects and decided at compilation time, then we return to a solution quite similar to the first alternative. The proxy must somehow be created according to the communications needs
30 and dynamically at run-time to achieve higher level of flexibility.

Figure 8 shows two run-time configurations. By domain, it is meant either user domain or telecom system domain. If

at run time CO1 and CO2 are within the same domains, then interactions are done through usual channels assuming of course that the access and location transparencies are supported within the domain. On the other hand, if they
5 are in different domains, e.g. one object in the user domain and the other in the telecom system domain, then a proxy is created to transfer all the interactions to the mobility functions which is responsible to deliver them to the other side. Neither CO1 nor CO2 need to be aware
10 that the proxy PCO2 exists. CO1 does not distinguish between PCO2 and CO2 when it is invoking operations. CO2 does not distinguish between PCO2 and CO1 when it is invoked. It should also be possible to design and implement PCO2 independently of both CO1 and CO2. It should also be
15 possible to create proxies dynamically at run-time when interactions across domain boundary are requested.

To fulfil the requirements mentioned above, we adopt the idea presented by OMG in the Dynamic Skeleton Interface
20 (DSI). The purpose for the introduction of the DSI is to enable the building of bridges interconnecting multiple, heterogeneous CORBA-compliant ORBs. However, the DSI is described in CORBA terminology and in CORBA-compliant manner which is not always consistent with the ODP/TINA
25 concepts. We shall attempt here to map all the ideas to the ODP world and give a description which fits better with our context.

The idea is to introduce an object type called Dynamic
30 Object (DO). All the proxies will be of type DO. A proxy, i.e. an object (instance) of type DO is instantiated from an object template called Dynamic Object Implementation (DOI). A proxy is hence semantically separated from the object it represents. The unique relationship which re-

mains between them is Represent, i.e. a proxy represents one and only one object. A proxy shall be deleted when the represented object terminates. An object can, however, be represented by multiple proxies, e.g. one proxy
5 for each client object. An information model is given in Figure 9.

The object type DO has a unique interface which consists of only one operation, namely Invoke, which is similar to
10 the Invoke operation previously shown.

For an arbitrary object to interact with an object residing in a remote domain, a proxy representing the remote object must be present in the local domain. There are now
15 two problems to solve. First, when an object invokes an operation on a remote object, the invocation must be re-directed toward the proxy. Both a naming conversion and an object type conversion are necessary because the client generates an operation request using the reference of
20 the remote server which implicitly refers to the object type of the server object. Second, the operation request must be translated and marshalled into the Invoke operation which is the only operation of the proxy.

25 To preserve transparency, these two problems must and can only be solved in the Engineering viewpoint and not in the Computational viewpoint. Correspondence must, however, exist between the two viewpoints.

30 Let us reconsider the example of a computational object CO1 invoking an operation OpX on a remote computational object CO2. When requesting an operation OpX on CO2, CO1 has to specify the Computational Interface Identifier (CII, also called Computational Interface Reference in

TINA [TIN95a] of the interface I2 of CO2, (say CO2.I2) and the operation name OpX plus all the necessary operation arguments.

- 5 Let us now move to the engineering viewpoint. Suppose that CO1 and CO2 are mapped to the basic engineering objects BEO1 and BEO2, respectively. Depending on the application designer's decision, the operation request can be built in a static way before compilation or dynami-
- 10 cally at run-time. This will lead to different types of stubs that should be linked and compiled together with the programming code of BEO1. In the first case, the generated stub is specific to the interface CO2.I2 while in the second case the stub is generic and can be used by
- 15 any object and in any binding. Dynamic Invocation Interface is an example of the second case. However, in both cases, the engineering operation request must contain the same information as the corresponding computational operation request, i.e. the Computational Interface identifier, the operation name and parameters.
- 20

At run-time, when an operation request is issued, a channel must be established to interconnect the involved basic engineering objects. The necessary information to

25 create a channel is contained in an Engineering Interface Reference (EIR) [ITUc]. Contrary to the CII, the EIR is both time and space dependent. The relationship between CII and EIR is shown in Figure 10.

- 30 The DPE or more specifically the nucleus of the DPE node where the call is issued,, will be implicated to map the incoming CII to an EIR. This can be done in different ways, for instance, as an exception call in the stub code. The EIR will be used to establish the channel.

In our example, no EIR will be found for BEO2 since it is residing in another domain. Here, the DPE can be equipped with a redirection function which maps the incoming CII, i.e. the CII of BEO2, to the EIR of the proxy PBEO2 instead of the EIR of BEO2. The mapping is forced in the sense that the proxy PBEO2 does not support the interface CO2.I2 and the operation OpX. A channel can now be establish between BEO1 and PBEO2. When the operation request arrives at the end of the channel, a conversion is necessary before the delivery to PBEO2. The server stub of PBEO2, instead of performing the usual unmarshalling of the request, has to convert it and pack it into the operation Invoke of the PBEO2 which may look like this:

Invoke (CO2.I2, Context, OpX, Arguments, Result)

The OMG's Dynamic Skeleton Interface allows indeed the specification of such flexible interface for a server object and the generation of stub from the interface specification. By this technique, the interface and operation name specified by the client object does not have to match with the interface and operations defined at the server object and can be compiled separately. In CORBA revision 2.0, there is also defined a redirection function as described above which supports the DSI.

The operation Invoke of PBEO2 can now be designed to contain a call to the operation Invoke of the user agent of the mobility functions. By this way, the operation request is passed to the mobility functions and conveyed from one domain to the another domain across the boundary. When receiving the request, the user agent in the other domain will invoke the operation OpX() on BEO2. The

result can then be conveyed the same way back, first to the PBE02 and then finally to BE01. In Figure 11, the additional redirection function of the DPE and the special server stub of PBE02 are emphasised by using darker colour than on other DPE's objects.

By using the proxy objects as described above, greater flexibility is achieved. The application designer does not have to perform the domain allocation of his objects, i.e. to decide which objects should be allocated to which domain in the implementation phase. Only the usual grouping of objects into clusters, capsules and nodes is required in the transition from the computational viewpoint to the engineering viewpoint. Necessary stubs and skeletons can then be generated automatically from the computational specifications by the development tools. The application designer can proceed with the implementation of application specific programming code. The implementation of the application is completed with the linking and compilation of the application code and the generated stubs.

The definition and creation of proxy objects can be postponed until the configuration and deployment of the application. Depending upon the chosen configuration, the necessary proxy objects will be identified and defined. The proxies can be created at the initialisation of the application and remain alive during the whole life time of the application. They can also be created dynamically according to the interactions and terminate upon the completion of the interaction.

Any object wanting to interact with objects in a different domain must be registered in the mobility functions. The registration of the necessary objects for an applica-

tion can be done at the initialisation by an object which is customised for the configuration. The definition and creation of a proxy can be conveniently done together with the registration of the object it is representing.

5

In order to recapitulate what is achieved in this alternative, let us return to the same example considered in the two previous alternatives with for computational objects CO1, CO2, CO3 and CO4. In this alternative, it is not necessary to do the domain grouping in the transition from the computational viewpoint to the engineering viewpoint. Only the grouping of objects into clusters, capsules and nodes is performed. CO1 and CO2 belong to the cluster 1, CO3 to cluster 2, CO4 to cluster 3. The clusters 1, 2 and 3 are respectively within capsule A, capsule B and Capsule C. From this computational model, an Engineering model is derived and the necessary stubs are generated. Between CO2 and CO3, there is a need for a channel. The same applies to CO3 and CO4. Note that in this model all objects, clusters, capsules and nodes are considered as if they are all located within the same domain. The application designer can now add application specific programming code and execute the linking and compilation. The design and implementation of the application is then completed.

At installation, the plant engineer configures the application according to the request of the customer. Based on the configuration, he can derive the registration of objects to the mobility functions and the creation of necessary proxies (see Figure 12).

This alternative yields very high level of flexibility. The inconveniences are the requirement for a new redirec-

tion function on the DPE and the possibility to generate special stub for the dynamic objects. These two inconveniences are however insignificant since DPE's such as CORBA revision 2.0 implementations already include these
5 features.

MERITS OF THE INVENTION

- 10 • By introducing Mobility transparency, i.e. hiding the mobility functions to the applications, the design and implementation of mobile applications will be no more complex than the designing and implementation of fixed applications.
- 15 • Existing fixed applications may be transformed to mobile application, i.e. made available to mobile users without any modification.

REFERENCES

- | | |
|----|---|
| 5 | <p>[ITUa] ITU-TS. Basic Reference Model of Open Distributed Processing - Part 1 Overview and guide to use the Reference Model. Rec.X901(ISO/IEC 10746-1).</p> |
| 10 | <p>[ITUc] ITU-TS. Basic Reference Model of Open Distributed Processing -Part 3: Prescriptive model. Rec. X903 (ISO/IEC 10746-3).</p> |
| 15 | <p>[Obja] Object Management Group, Inc. The Common Object Request Broker: Architecture and Specification. Document No. 91.12.1, Revision 1.1, ISBN 0-471-58792-3.</p> |
| 20 | <p>[Objb] Object Management Group, Inc. The Common Object Request Broker: Architecture and Specification. Revision 2.0, July 1995.</p> |
| 25 | <p>[OPR96] Randy Otte, Paul Patrick, and Mark Roy. Understanding Corba - The Common Request Broker Architecture. Prentice Hall PTR, 1996.</p> <p>[TIN95a] TINA-C. Computational Modelling Concepts, January 1995.</p> <p>[TIN95i] TINA-C. Overall Concepts and Principles of TINA, February 1995.</p> |

P a t e n t c l a i m s

1. Arrangement for simplifying the design and implementation of mobile services in a communication system, especially a telecommunications system, said system comprising distributed hardware and software components which interact in order to provide services to one or more users,
c h a r a c t e r i z e d by introducing in said system a mobility transparency, for thereby enabling facilitated application design including inter alia terminal or personal mobility.
2. Arrangement as claimed in claim 1,
c h a r a c t e r i z e d i n that said mobility transparency is adapted to hide all the necessary mechanism and functions, for thereby supporting mobility to the application in question and to the application designer.
3. Arrangement as claims in claim 1 or 2,
c h a r a c t e r i z e d i n that said mobility transparency is to be considered as a new transparency in addition to already existing transparency, for example in addition to the one defined by ODP (Open Distributed Processing) and adopted by TINA (Telecommunication Information Networking Architecture).
4. Arrangement as claimed in any of the claims 1-3,
c h a r a c t e r i z e d i n that mobility transparency is introduced to the application designers at the requirement and functional specification phases, i.e. by integrating mobility function (M) totally into the infrastructure of platform.

5. Arrangement as claimed in any of the preceding claims,

characterized in that computational objects are mapped to engineering objects (EO) so as to be none-visible in the computational model of the application in question.

6. Arrangement as claimed in any of the preceding claims,

characterized in that the mobility function constitutes the engineering object interceptor, i.e. being arranged at the boundary between the terminal domain and the telecom system domain.

15

7. Arrangement as claimed in any of the preceding claims,

characterized in that an engineering model is developed by letting each computational object (CO) be mapped to one or more Basic Engineering Objects (BEOs), interaction between computational objects (CO1, CO2) belonging to the same cluster being effected directly as method calls, and communications between computational objects (CO3, CO4) located in the telecom system domain and in different clusters being effected through a channel comprising stubs, binders and protocols.

8. Arrangement as claimed in any of the preceding claims,

characterized in that communication between user domain computation objects (CO2) and telecom system domain computation object (CO3) residing in different clusters will take place in a channel comprising

an interceptor () in addition to the usual objects, said interceptor being invisible for the application designer.

9. Arrangement as claimed in any of the preceding
5 claims,

c h a r a c t e r i z e d i n that from the computa-
tional model the application designer can decide whether
an object belongs to the user domain or the telecom sys-
tem domain, for on the basis of such a decision to gener-
10 ate the necessary objects, such as stubs, for all the ap-
plication objects.

10. Arrangement as claimed in any of claims 1-3,
c h a r a c t e r i z e d i n that the arrangement
15 comprises means for sending a message to a routing broker
asking for specific server to perform a task, said bro-
ker locating the server and sending said request to said
server, said mobility functions (M) thereby playing the
role as the broker.

20
11. Arrangement as claimed in any of the claims 1-3 or
10,
c h a r a c t e r i z e d i n that said mobility
function (M) comprises a cascade of two brokers.

25
12. Arrangement as claimed in any of the claims 1-3 or
10-11,
c h a r a c t e r i z e d i n that said mobility
functions (M) in the form of two brokers allows for in-
30 teraction between an object (CO1) belonging to a user do-
main and an object (CO2) belonging to a telecom system
domain by letting said interactions enter said mobility
functions (M) at one end and exit therefrom at the other
end (Fig. 5).

13. Arrangement as claimed in any of the claims 1-3 or 10-12,
c h a r a c t e r i z e d i n that both ends of the
5 mobility functions (M) support both the same interface
type containing an "invoke type" operation, for thereby
allowing a request to be built and invoked dynamically by
client objects.

10 14. Arrangement as claimed in claim 13,
c h a r a c t e r i z e d i n that there is used an
invoke operation, which invoke comprises an object name
(or identifier), an operation name, and a parameter list
for the invoked operation.

15 15. Arrangement as claimed in any of the claims 1-3, or
10-14,
c h a r a c t e r i z e d i n that the mobility func-
tions (M) are introduced in the system architecture as a
20 functional layer between the application layer and the
DPE layer, said layer separation allowing every layers to
use services offered by other layers.

25 16. Arrangement as claimed in any of the claims 1-3, or
10-15,
c h a r a c t e r i z e d i n that there is intro-
duced an intermediary model called derived computational
model in the transition from the computational model to
the engineering model, said intermediary model being used
30 to map all interactions traversing the boundary between
the user domain and the telecom system domain to interac-
tions with the mobility functions (M).

17. Arrangement as claimed claim 16,

c h a r a c t e r i z e d i n that on the basis of the derived computational model, an engineering model can be elaborated and engineering objects, such as stubs, can be mechanically generated.

5

18. Arrangement as claimed in any of the claims 1-3, c h a r a c t e r i z e d i n that said arrangement comprises proxy objects, a proxy acting on behalf of an entity in a transparent way, i.e. when interacting with a proxy an entity cannot tell whether it is dealing with the real counterpart or with its proxy.

19. Arrangement as claimed in claim 18, c h a r a c t e r i z e d i n that the proxy is adapted to marshall the operation invocation into an invoke operation at the respective end of the mobility functions (M).

20. Arrangement as claimed in claim 19, c h a r a c t e r i z e d i n that the proxy is introduced as a symmetrical constellation if interactions are to be in both directions.

21. Arrangement as claimed in claim 20, c h a r a c t e r i z e d i n that the necessary proxies are introduced and created according to the communications needs, alternatively dynamically at run-time.

22. Arrangement as claimed in any of the claims 1-3 or 18-21, c h a r a c t e r i z e d i n that there is introduced an object type designated Dynamic Object (DO), all proxies being of the type DO, and that a proxy, i.e. an

object (instance) of type DO is initiated from an object template called Dynamic Object Implementation (DOI).

23. Arrangement as claimed in claim 22,

5 c h a r a c t e r i z e d i n that a proxy represents one and only one object, a proxy being deleted when the represented object terminates, alternatively that an object can be represented by multiple proxies, e.g. one proxy for each client object.

10

24. Arrangement as claimed in any of the claims 1-3 or 18-23,

c h a r a c t e r i z e d i n that any object wanting to interact with objects in a different domain are registered in the mobility functions (M), the registration of
15 the necessary objects for an application being done for example at the initialisation by an object which is customised for the configuration, the definition and creation of a proxy conveniently being done together with the
20 registration of the object it is representing.

25. Arrangement as claimed in claim 24,

c h a r a c t e r i z e d i n that only the grouping of objects into clusters, capsules and nodes is performed, all objects, clusters, capsules and nodes being
25 considered as if they are all located within the same domain, the application designer adding thereto specific programming code and executing the linking and compilation.

30

26. Arrangement as claimed in any of the claims 1-3 or 19-25,

c h a r a c t e r i z e d i n that there is introduced a new redirection function on the DPE in question,

as well as the possibility of generating special stub for any dynamic objects.

1/7

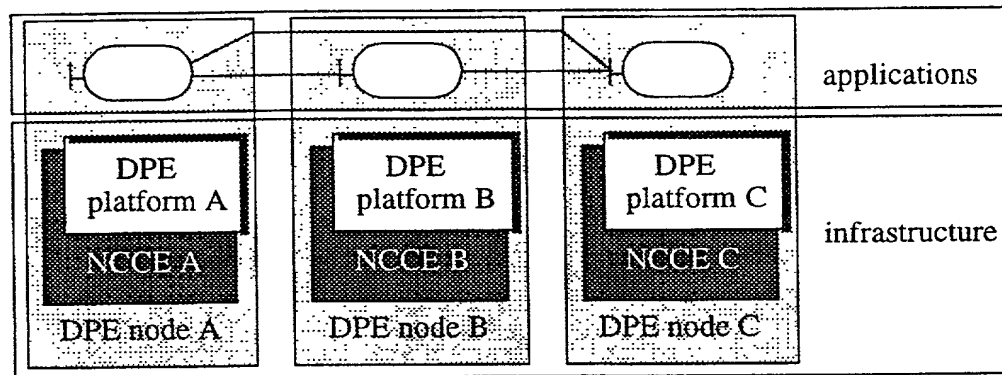


Figure 1 Physical Infrastructure

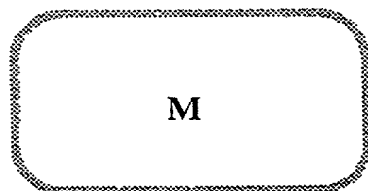


Figure 2 M represent all the mobility functions

2/7

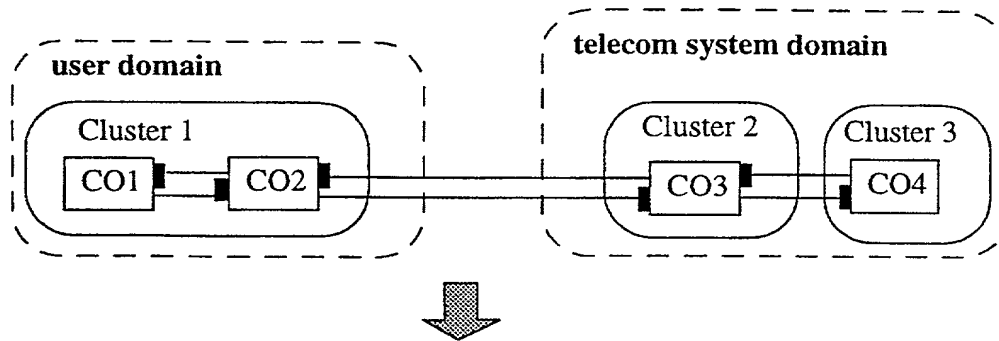
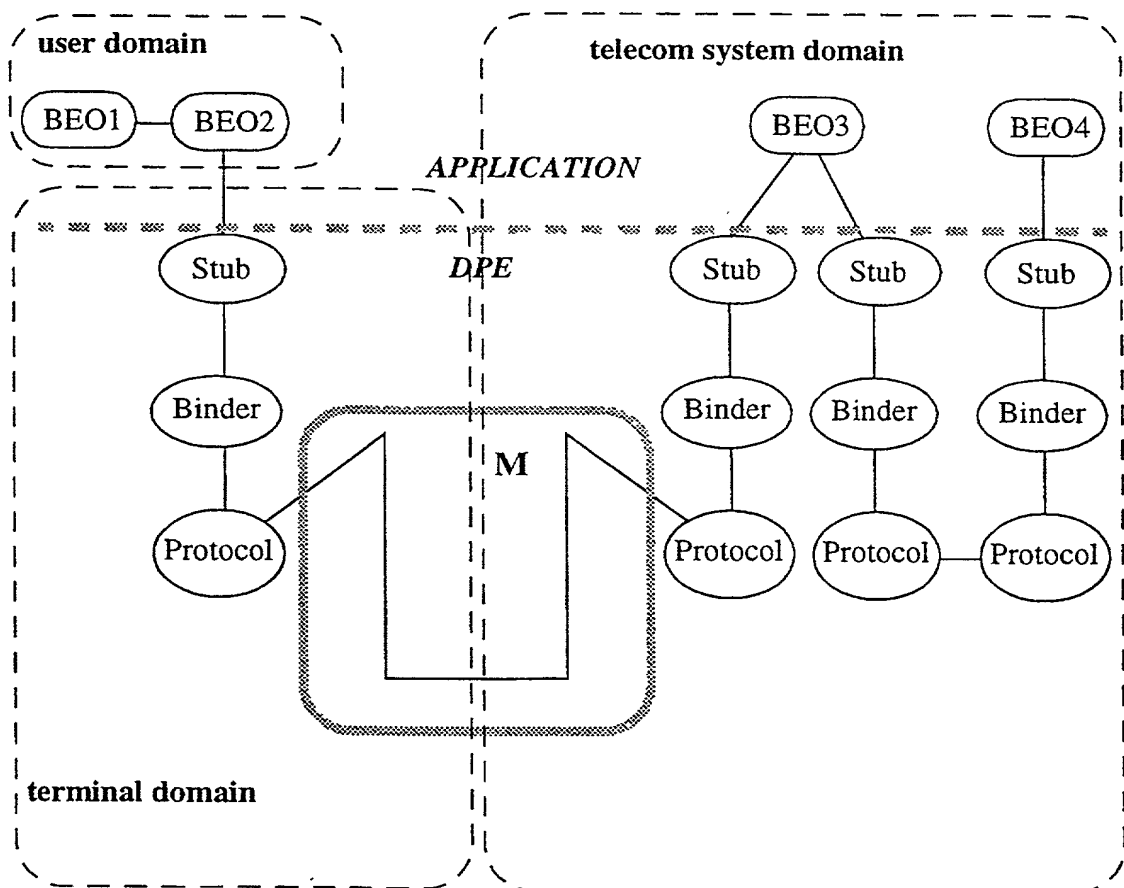
Computational Model of the application**Engineering Model of the application**

Figure 3 The In-line alternative

3/7

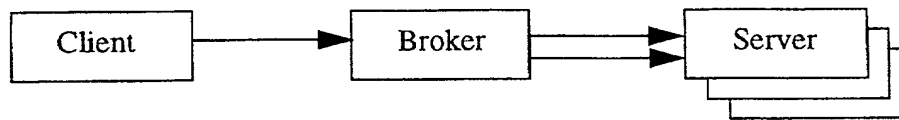


Figure 4 Using broker in client /server interactions

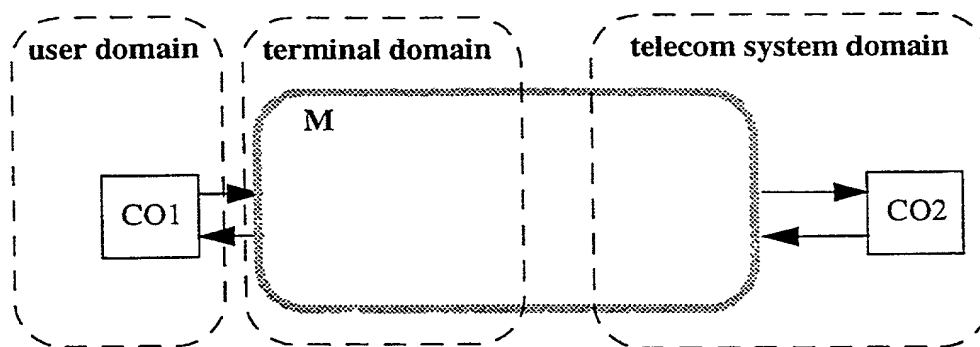


Figure 5 The user agents acting as routing brokers

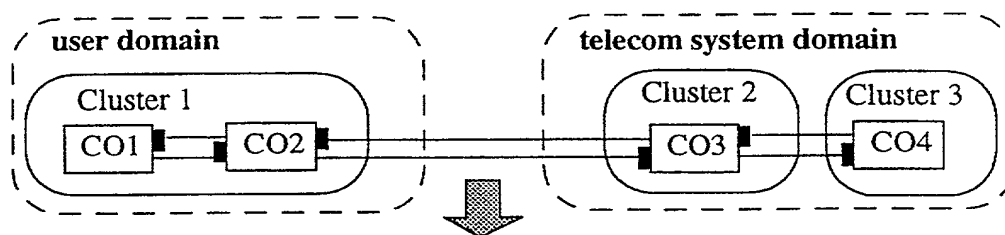
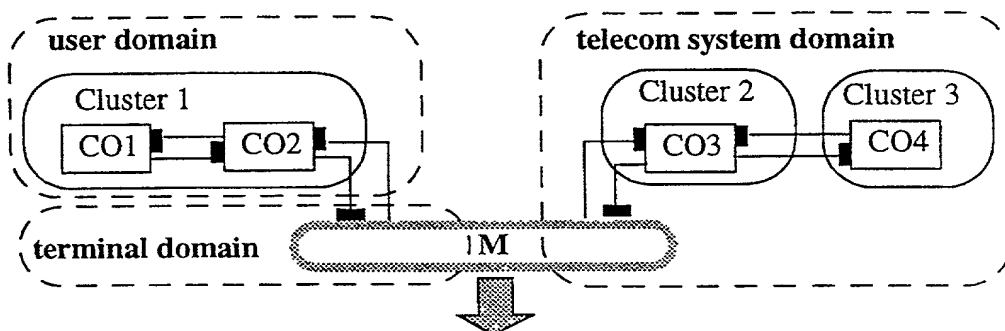
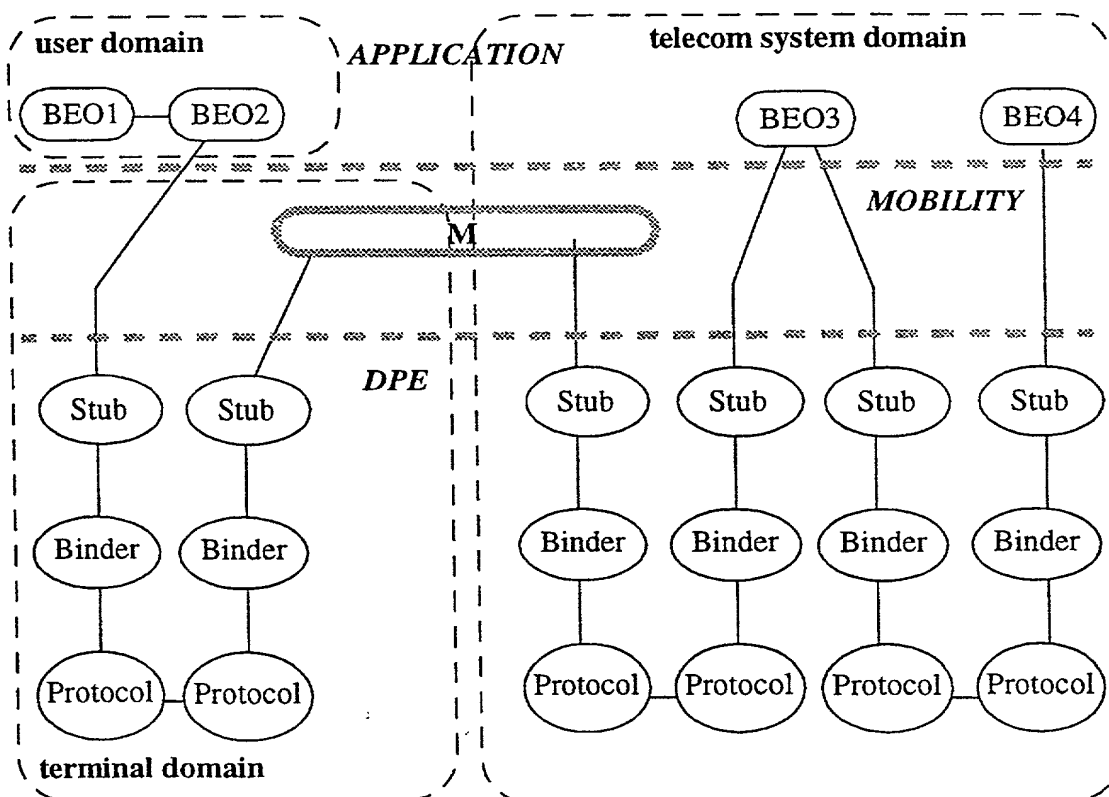
Computational Model of the application**Derived Computational Model of the application****Engineering Model of the application**

Figure 6 The broker alternative

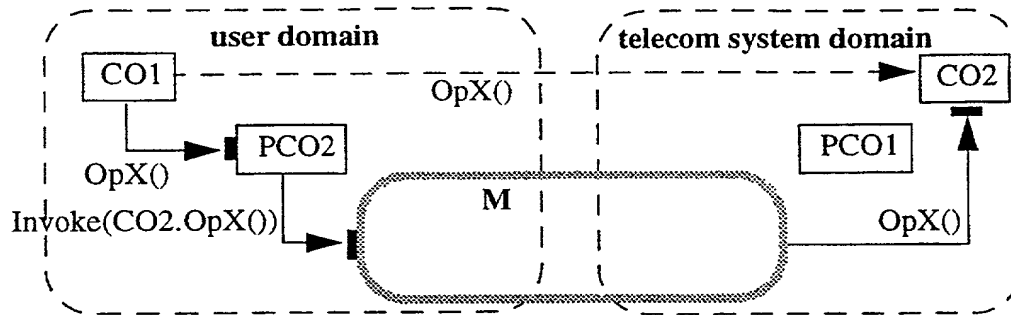


Figure 7 Using proxies to untie the binding between the application and the mobility functions M

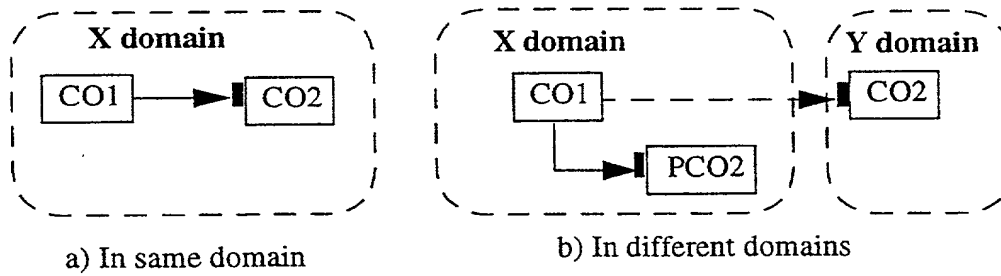


Figure 8 Possible configurations at run-time

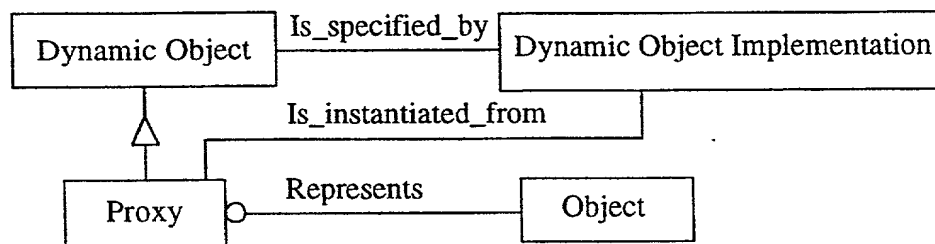


Figure 9 Information model for the Proxy

6/7

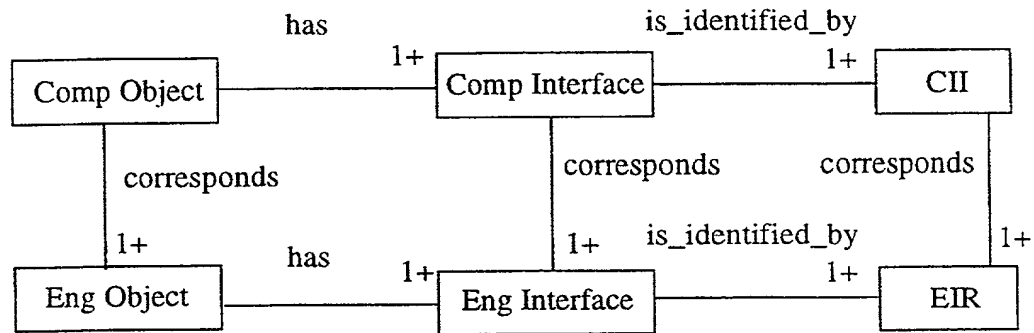


Figure 10 Relationship between objects, interfaces and identifiers in the computational and engineering viewpoints.

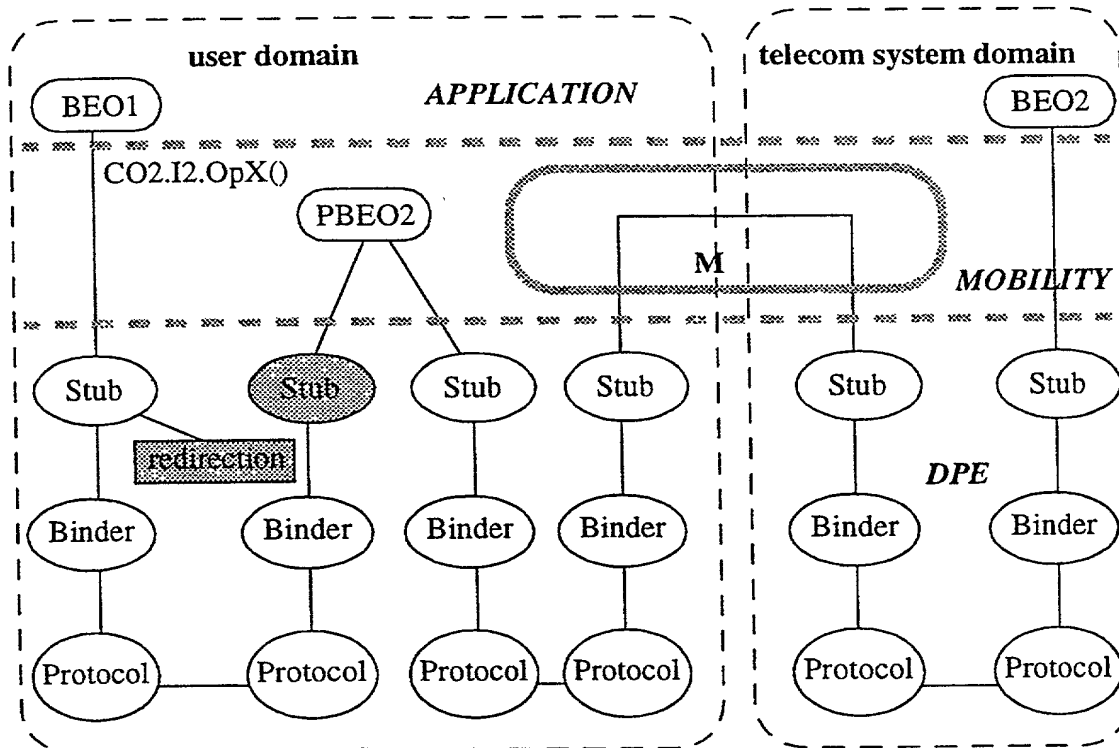


Figure 11 The redirection of operation request to the proxy

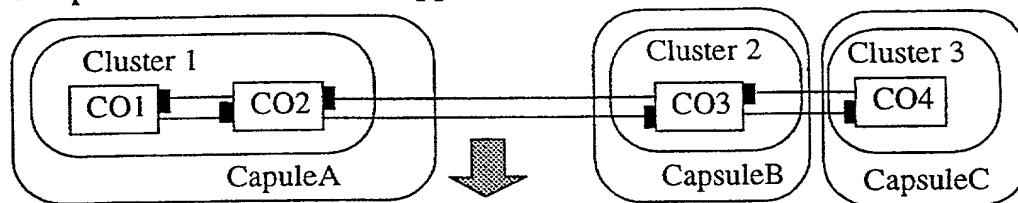
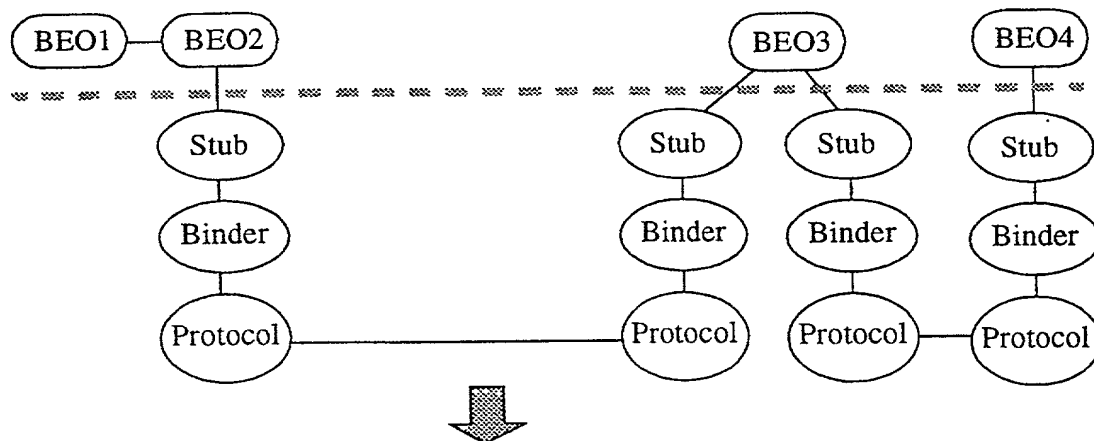
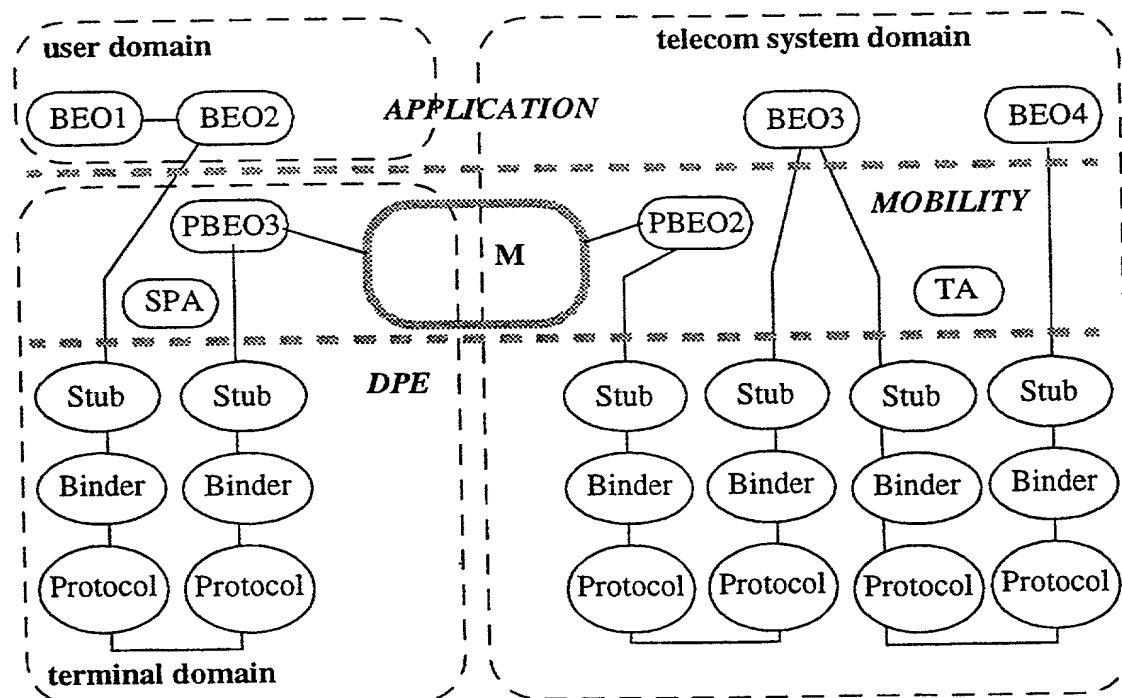
Computational Model of the application**Engineering Model of the application at compile time****Engineering Model of the application at deployment**

Figure 12 The Proxy alternative